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PLANT PATHOLOGY IN ITS RELATIONS TO OTHER SCIENCES

IN the naming of this association of scientists, The Illinois Academy of Science,[1] there was recognized a very subtle tendency in advancing civilization and modern educational thought. It has often been noted that as civilization becomes more highly developed, it also becomes more complicated, and men become more dependent upon one another. So, too, as knowledge increases in volume and in extent, the fields of study which were formerly quite independent grow closer together, and, new fields opening up, find themselves involved with many others already existing. We are finding, in fact, that knowledge is a unit—not a mere assemblage of disconnected ideas, so that it is advantageous, now and then, to examine a new science, and to discover, in so far as we can, with what other parts of the body of science it may be intimately related. Therefore, it has seemed advisable to consider, this morning, how plant pathology is related to other sciences.

Plant pathology is one of the youngest, and perhaps one of the least understood, of the recently developed sciences. When considered in its broadest meaning, it is for plants, as medical science is for man, a study of the normal, and of the diseased conditions of the organism. In the narrower and more widely accepted sense, however, it deals with the abnormalities

[1] This paper was read before the academy at its first regular meeting, held at Decatur, Illinois, February 22, 1908.

both of form and of function, which in animals are, and in plants may be, called diseases. There is one other phase also which must always appear, that of the prevention and the cure of the maladies.

Few people who have not studied the matter realize the very large loss of money occasioned each year by these plant diseases, and fewer yet know that much has already been done to diminish this loss, and much more will be done when more scientific and detailed study is carried on by a larger number of investigators scattered widely over the country. A conservative estimate of the loss caused by the bitter rot of apples throughout the country each year, is ten millions of dollars. In the state of Illinois, the loss, due to corn rot, for the past year, is estimated at perhaps two hundred and eighty thousand dollars. But we want to know what may be done to reduce such losses. It is a part of the work of the plant pathologist to discover how this may be done, and for many diseases a remedy has been found.

By proper spraying methods, on a commercial scale, ninety per cent. of the loss from peach yellows has been saved. Oat smut has nearly lost its terrors for the scientific farmer, because of the method of "seed" treatment which kills the smut spores. In New York a properly sprayed vineyard gave a net profit of over fifteen hundred dollars more than the same vineyard, unsprayed, yielded the previous year. Diseases of various origins have been treated and the loss caused by them has been materially reduced. Moreover, the importance of this work is increasing with the growing population, for crops are becoming more extensive and crowded, a condition which gives two of the important factors that tend to produce great epidemics of diseases.

The science of plant pathology, like bacteriology, is very closely related to botany, and in a broad classification of the sciences would be considered a part of that great subject. Yet, with equal justice, it may be considered as a separate science, closely related, first to botany, then to zoology, chemistry and physics.

The affiliations with botany are varied and strong. If we consider those diseases which are caused by parasitic fungi, as rusts, mildews and so forth, or by bacteria, as many "wilts" of garden plants, or even by the parasitic flowering plants, such as the dodder and the mistletoe, we must first know the names and the systematic relations of these invading organisms. Here at the outset we come in touch with that great department of the science, systematic botany, which, for very many years, engaged the entire attention of botanists.

Hand in hand with this first part of the investigation goes the study of the morphology of the parasite, for to determine the name we must know the peculiarities of form and of structure which distinguished it from all of its relatives. Moreover, the parasite, if it grows on two or more different plants, may show various modifications of its own form, according to the plant on which it happens to develop. Thus, the common grain rust, *Puccinia graminis*, when growing on its alternate host-plant, the barberry, produces entirely different kinds of spores from those on the grains. Pathology and morphology cross paths also at another point. A large and important field of study now being developed is that of the correlation of the natural structure of the plant attacked, with the modifications due to the disease. This work is essential for two reasons. We may thus learn, in regard to diseases caused by organic beings, in what manner the parasite attacks and destroys the host-plant. A disease, however, may not be caused by an organism,

but may result from certain known or unknown improper physical conditions of the plant's environment. Hence this study may result in a better differentiation between these so-called "physiological diseases," and the derangements caused by parasites.

Plant physiology is no less important in the study of plant diseases than morphology. We must know the normal functions of the plant attacked, and be able to realize in what way they have been deranged. Thus, if a parasite is the cause of the disease, it may bring about the death of the host-plant in one or more of the following ways: It may strangle the plant by clogging the water-conducting vessels, as in the bacterial "wilt" of melons, already referred to. Again, it may give out a poison which kills the protoplasm of the cells affected, as De Barry describes for one of the *Sclerotinia* diseases. The third method is by absorbing the food, water or the protoplasm itself, from the cells of the host. This seems, at the present time, to be the most common mode of attack, especially in those diseases, like leafspots, which remain localized in some organ. When an organism has the power of injuring more than one kind of plant, its own functions may be modified according to varying conditions. This is important in seeking means of curing or of preventing the disease. A good example is the common grain rust mentioned previously, which, though identical in form and appearance, on wheat, oats and rye, can not be taken from any one of the three hosts and grown on either of the others.

Plant pathology not only owes much to these departments of botany, but also to bacteriology. Laboratory methods which have been found useful in the latter have been adapted to the somewhat different needs of the former. The use of culture media, though not so absolutely necessary for elementary work in pathology as it is in bacteriology, is, however, very common, and, doubtless, special media for special organisms are more numerous here than in the allied science. Since Dr. Burrill, of the University of Illinois, demonstrated in 1879 that in one instance, at least, the pear blight, a plant disease might be caused by bacteria, many diseases have been shown to be of similar origin, and here, naturally, the pathologist becomes very closely allied with the bacteriologist.

Of more and more importance to the country is forestry, on which, eventually, large portions of the land must depend for rainfall and for timber. With this is closely allied our science of plant pathology. There are many diseases of trees, which, unless curbed, threaten the growing of forests. One need but to refer to the "punk" disease of the longleaf and of the shortleaf pines and to similar decays of other forest trees, to justify this claim. Indeed, this is so important that a forest pathologist has recently been appointed by the government to study these diseases more carefully. It is unnecessary to dwell upon the increasing importance of the science to agriculture, for we have already noted their close relation.

We have seen that botany in all its phases is intimately associated with the study of plant diseases, but now we will consider what other sciences have an interest in it.

We turn naturally to zoology as the science next to botany, and in many ways it may well be so considered. To plant pathology it is related chiefly through the pathological conditions which arise as a result of the attacks of various worms, insects and even higher animals. In this way, many galls, such as the well-known oak-galls and the nematode root-gall, which inflicts so much damage, originate. The stripping of the leaves from trees, and the

ever-present injuries to farm products cause conditions for pathological study. Many diseases are transferred from plant to plant by animals of nearly all classes, and the combined efforts of zoologists and of pathologists will be necessary to combat this evil. Dr. Erwin F. Smith enumerates bees, the potato beetle, snails and slugs as known transportation agents for various diseases. Moreover, we do not yet know how many diseases of animals, both domesticated and wild, may be due directly or indirectly to plant diseases. Cases have been reported where serious results have attended the feeding of diseased fodder to live stock; and flour, made from infested grain, may cause serious results in man.

The relations between plant pathology and chemistry are perhaps more intimate, but at first glance less apparent than those already noted. The most obvious connection is through the work which the chemist and the pathologist have done together in developing the manufacture and the use of fungicides. To the farmer, this has seemed the most practical side of pathological work, because of the immediate results in saving crops. A less noticeable but even more important contribution of chemistry is the analysis of soils and of fertilizers, by which we can better know the conditions of optimum growth for various crops, and the best conditions for growing plants which are resistant to disease. The good resulting from this kind of investigation can not be overestimated, for, as a man in good physical condition is able to resist the attacks of many diseases, so a plant, if given the best conditions for growth, will be able to combat the various parasitic organisms which would otherwise destroy it. In another way chemistry will prove in the future a valuable ally in studying plant diseases. In the healthy plant certain products of growth are formed whose chemical nature must be known. When the plant is diseased, these organic compounds, acted upon by the enzymes produced by the attacking organism, or otherwise changed in composition, must be examined again to determine the nature of the change.

The relations existing between plant pathology and physics are not so well defined as in the cases already cited. If, however, we keep in mind that there is, in the study of botany, a physical as well as a physiological side, these relations are more easily seen. The ascent of water in trees; the conduction of water, food-elements and foods, and reaction to gravitation and to other physical stimuli are problems which the physicist must aid us in solving, though connected with these there are undoubtedly many vital processes which modify the mere physical forces. In a diseased plant the effects of these physical forces are modified probably more than we now realize. We may mention as examples of these modifications the stoppage of water-conducting elements in woody plants, the weakening of the tenacity of wood, and similar changes in the physical conditions of plants.

This is not the place to state more definitely the problems in plant pathology waiting to be solved with the aid of other sciences, but we may note in closing that in the past the interrelations of the sciences have not been entirely disregarded, for such men as Pfeffer and Pasteur, by using methods of sister sciences, have made valuable additions to our knowledge of botany.

Ernest Shaw Reynolds

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